Glucometer: Senior Design Proposal

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1 Introduction

The world is becoming more connected everyday. People are using technology to monitor everything from their activity to their diets. We want to design a marketable diabetes blood glucose monitor that connects to any smartphone through Bluetooth and also combines three products (glucometer, lancing device, and test strip cartridge) into a single compact device. This will bring blood glucose monitoring to the 21st century and makes the lives of diabetics easier.

2 Problem Description

Diabetics need to monitor their blood sugar on a regular basis and deliver insulin or glucose to their body since it does not do this naturally for them. Controlling diabetes is hard and requires constant attention. Part of this difficulty stems from the fact that it can be tough to remember the last time you took a blood sugar or gave insulin. If you are a newly diagnosed diabetic, this is extremely difficult, especially for young children. However, remembering is the least of a diabetics worries. They have to remember to bring their blood glucose monitoring kit, which includes a glucose monitor, test strips, a lancing device, alcohol cleaning pads, and something to record their blood sugar. All which are easy to forget and may require maintenance or replacement, not to mention they all must be carried and are bulky. The day in the life of a diabetic is consumed with managing their disease. We want to help free up some of the worry with our blood glucose monitoring system, which will be compact, connected, easy to use, and hard to forget.

3 Proposed Solution

Our solution focuses on providing an all-in-one device to measure and manage blood glucose levels. Our device will include a lancing device, a glucose meter, and a test strip cartridge, all of which will attach to existing insulin pens. The result is one single device that diabetics will carry with them, as opposed to the current solution where they are responsible for three separate devices – lancing device, glucometer, and pen. This device will also enable users to upload their readings to a mobile app. This allows for easy tracking of glucose levels over time and also provides a platform for sharing reading data with doctors or, for children, parents.

4 Demonstrated Features

· Hold a standard size cartridge of test strips
· Provide a lancing device that will prick the user's finger to draw blood. This lancing device will contain a small needle that will be cocked back manually.
· A slot to insert the test strip into the glucometer.
· A microcontroller with analog to digital converter to generate a blood sugar reading.
· A microcontroller that can calibrate to multiple test strips
· A small screen LCD display to show the blood sugar reading, as well as give a basic user interface to show battery life, Bluetooth connectivity, etc.
· A Bluetooth chip to send to the user's smartphone.
· A smartphone app that will store user's data, help interpret blood sugar readings, provide literature on diabetes, allow communication with their physician, and send reminders to check blood sugar.
· Either replaceable watch button batteries or micro-USB rechargeable battery
· Packaged in a sleek design that will comfortably attach to the user's insulin pen.

5 Available Technologies

Glucometer – Microcontroller and LCD

We will use an existing microcontroller and LCD screen and implement it to generate a blood sugar reading. Here are the features we are considering.
Microcontroller:
· Analog to digital converter
· Small, must fit within a confined space
· Low power
· Serial output
LCD screen
· Low power
· Serial input
· Minimum 3 digit display
· Other dot LCD's to signal power on, Bluetooth connected, etc.

Bluetooth Low Energy

There are two options for implementing Bluetooth Low Energy in our device – using an integrated System on a Chip (SoC) that includes a microcontroller and Bluetooth transmitter, or including a

dedicated Bluetooth chip that will interface with a microcontroller. The following two devices seem appropriate for our device.

- Texas Instruments CC2540
    - This is a SoC solution that also includes memory, and depending on our needs may be sufficient to control our device.

- Nordic Semiconductor nRF8001
    - This is simple Connectivity IC that will need a microcontroller

Battery

We are considering two options for the battery – a rechargeable battery or a replaceable coin cell. Multiple coin cells could also be used depending on power needs. The most important considerations for this are size, cost, and power requirements. Right now we are leaning towards coin cell batteries – the following option appear to suit our needs.

- CR2032 button cell lithium battery
    - This is a button cell lithium battery with a capacity of 225mAh and a nominal voltage of 3.0V. Our microcontroller will likely need a higher voltage, so our circuit would need to account for this by stepping up the voltage or using more than one CR2032.

General:

Test Strips: One Touch Ultra Test Strips
iPhone, Android Smartphone
Mechanical lancing devices
Test Strip Cartridge

6 Engineering Content

Glucometer

The main engineering problems with the glucometer come with the microcontroller and designing a circuit board that will fit within our packaging constraint. The microcontroller will have to be programmed to give the most accurate and fast reading while optimizing its power consumption. The circuit board will require the majority of the engineering effort because it must be able to fit within the size of a large pen cap. This will possibly require a round circuit board with multiple layers or skinny rectangular boards lying vertically in our system. Other factors that will need to be considered are the lancing device protruding through the board, and how best to connect it to the battery.

Bluetooth

The engineering problems surrounding Bluetooth connectivity are data transmission and communication with the microcontroller. Data needs to be transmitted from the microcontroller to the Bluetooth radio, and then from the Bluetooth radio to the connected Smartphone. Power consumption is also an important consideration. The goal for the Bluetooth aspect of the device is to design a system that minimizes power consumption while ensuring all data is reliably transmitted to the device.

Battery

We are seeking to minimize power consumption in our device and to utilize the smallest battery possible that affords our device a decent battery life. The battery aspect of the device is largely dependent on the way we design the circuit and how much power it needs.

Smartphone App

A smartphone app that will connect to our glucometer using bluetooth, store user's readings, help interpret blood sugar readings, provide literature on diabetes, allow communication with their physician, and send reminders to check blood sugar. This will require a fully architected backend to record any data acquired by the user. Also, it will need to be able to be used on multiple types of smartphones: Android, iOS, and Windows. Therefore, we are creating a web app, which allows us to create a more cross platform solution.

Device Casing

Part of our team is a mechanical engineer who will be working on finding unique ways to make a glucometer, a lancing device, and a test strip cartridge fit compactly into our design. Furthermore, the overall design will be an attachment to insulin pen delivery systems. Thus, the casing will need to be able to attach to the insulin pen in a non-invasive way. This requires significant CAD design skills and ingenuity, especially since insulin pens do not all have the same form factor.

7 Conclusions

At this point, we suspect that a few aspects of the design will be most difficult. First, obtaining the desired size for our device will require optimal performance from the various aspects of our project, including the circuits, battery, lancing device design, and cartridge storage. Second, power consumption is also a large concern - we wish to achieve good battery life without sacrificing performance or features while still maintaining a small form factor. It is important to give the diabetic the ability to use the device for a long time without needing to replace the battery. Third, the smartphone app needs to be flexible enough to work on most smartphone devices. This may prove to be difficult since there are so many phones with different form factors.

Overall, this project will be tough since medical devices take long to develop properly because they an issue in the device could lead to hurting a patient. We will aim to create a fully functional prototype by the end of the year, understanding that most medical devices take multiple prototypes before they are ready to commercialize.